

INSTRUCTION MANUAL



SDM-AO4 Four Channel Analog Output Module

Revision: 4/09



Copyright © 1986 - 2009
Campbell Scientific, Inc.

Warranty and Assistance

The **SDM-AO4 FOUR CHANNEL ANALOG OUTPUT MODULE** is warranted by CAMPBELL SCIENTIFIC, INC. to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless specified otherwise. Batteries have no warranty. CAMPBELL SCIENTIFIC, INC.'s obligation under this warranty is limited to repairing or replacing (at CAMPBELL SCIENTIFIC, INC.'s option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CAMPBELL SCIENTIFIC, INC. CAMPBELL SCIENTIFIC, INC. will return such products by surface carrier prepaid. This warranty shall not apply to any CAMPBELL SCIENTIFIC, INC. products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CAMPBELL SCIENTIFIC, INC. is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. The following contact information is for US and International customers residing in countries served by Campbell Scientific, Inc. directly. Affiliate companies handle repairs for customers within their territories. Please visit www.campbellsci.com to determine which Campbell Scientific company serves your country. To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC, INC., phone (435) 753-2342. After an applications engineer determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. CAMPBELL SCIENTIFIC's shipping address is:

CAMPBELL SCIENTIFIC, INC.

RMA#_____

815 West 1800 North

Logan, Utah 84321-1784

CAMPBELL SCIENTIFIC, INC. does not accept collect calls.

SDM-AO4 Table of Contents

PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.

1. Function	1
2. Specifications	1
3. Power Supply	1
4. Physical Connections	2
5. Addressing	3
6. Programming	6
6.1 CRBasic	6
6.1.1 SDMAO4 Instruction.....	6
6.1.2 SDMSpeed Instruction.....	7
6.2 Edlog.....	8
6.3 Programming Examples.....	8
6.3.1 CR5000 Program Example	9
6.3.2 CR10X Program Example	10

List of Figures

1. Front Panel of the SDM-AO4.....	3
2. Locational Diagram for the Address Jumpers	5

List of Tables

1. Description of Terminal Block Connections	3
2. SDM-AO4 Addressing	4
3. Bit Period Value	7
4. Description of Instruction 103.....	8

SDM-AO4 Four Channel Analog Output

1. Function

The SDM-AO4 is designed to output four continuous voltages at levels set by a Campbell Scientific datalogger.

2. Specifications

Power Requirements

Operating voltage: 12 VDC Nominal (9.6 V - 16 V)

Typical current drain: 10.5 mA

Physical Specification

Size: 6.1" X 2.7" X 1.1"

Weight: 0.9 lbs.

Analog Output

Range: ± 5000 mV

Resolution 2.5 mV

Maximum Current 1 mA

Accuracy $\pm (0.5\% \text{ of } |V_{out}| + 5 \text{ mV})$

Minimum load

(for above accuracy) 75,000 ohms

Output Resistance¹ 200 Ohms

Temperature Range

-25 to +55 °C

¹ Output resistance can be viewed as a series resistance with the load the SDM-AO4 is driving. A low resistance load will cause appreciable error due to the voltage drop across the 200 ohm resistance. For example, the error (in addition to the accuracy specification above) with a 4800 ohm load = $200 / (4800 + 200) * V_{out} = 4\%$ of V_{out}

3. Power Supply

It is often convenient to power the SDM-AO4 from the datalogger power supply, but when doing so consideration must be given to the SDM-AO4's 10.5 mA continuous current drain. The alkaline supply available with the datalogger has 7.5 Amp-hours and will power one SDM-AO4 for less than one month. This supply is not recommended for continuous long-term operation. The rechargeable lead acid option, float charged by an AC supply or solar panel, may be used for long term operation.

The SDM-AO4 may also be powered from an external 12 Volt supply, independent from the datalogger supply. The low side of an external 12 Volt supply should be connected to datalogger ground and not directly earth grounded. Slight alterations in ground potential across the 21X terminal strip are created when the 21X 12 Volt supply is used to power peripherals. Therefore, low level voltage measurements (e.g., thermocouples, thermopiles, and radiometers) should be made differentially when powering the SDM-AO4 with the 21X 12 Volt output.

4. Physical Connections

Figure 1 shows the front panel of the SDM-AO4. The terminal block on the left is used for connection to the datalogger and the terminal block on the right provides the continuous analog output. The two ground ports on the left block are identical and at the same potential.

Table 1 describes the terminal block connections. Multiple SDM-AO4s may be used by connecting the datalogger side of one SDM-AO4 to the next. Campbell Scientific does not recommend connecting more than six SDM-AO4s to one datalogger.

The CABLE5CBL-L or similar cable is used to connect the module to the datalogger. A 1-ft cable length should be sufficient when both datalogger and module are housed within an ENC12/14 enclosure; a 2-ft length may be required if the datalogger and SDM-AO4 are housed at opposite ends of an ENC16/18 enclosure.

CRBasic dataloggers should use the SDMSpeed instruction if the cable length is longer than 20 feet (see Section 6.1.2). The maximum recommended cable length for the CR7 is 600 ft. For other Edlog dataloggers, the maximum recommended cable length is 20 feet.

CAUTION

Cables connecting the terminals of the datalogger and SDM device should be as short as possible to minimize the risk of corruption of the signal and damage from induced surges.

With power supplied to an SDM-AO4 and before execution of the datalogger program, a random voltage between ± 5 Volts will be output. To avoid outputting erroneous voltages to the receiving device, connect the SDM-AO4 to the datalogger, start the program, and then connect the receiving device.

CAUTION

The order of connections is critical. ALWAYS CONNECT GROUND FIRST, followed by 12V and then the Control Ports.

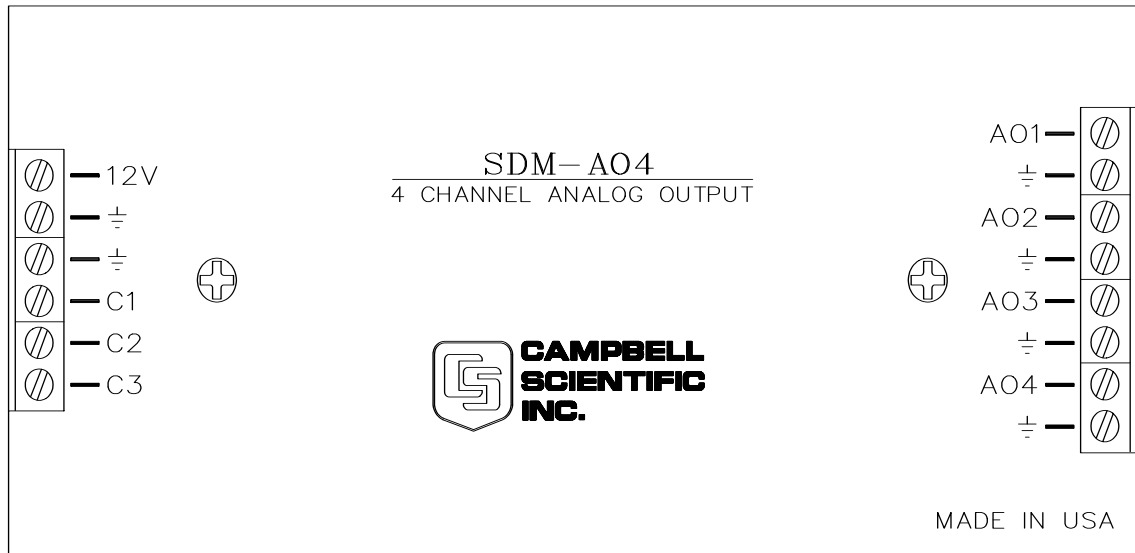


FIGURE 1. Front Panel of the SDM-AO4

TABLE 1. Description of Terminal Block Connections	
<u>Datalogger Connections</u>	
12V	- 12 volt supply - ground - ground
SDM-C1 (CR3000, CR5000) or C1	- SDM control port #1
SDM-C2 (CR3000, CR5000) or C2	- SDM control port #2
SDM-C3 (CR3000, CR5000) or C3	- SDM control port #3
<u>Analog Output Connections</u>	
AO1	- analog output #1 - ground
AO2	- analog output #2 - ground
AO3	- analog output #3 - ground
AO4	- analog output #4 - ground

CAUTION

The SDM-AO4 will not function correctly unless the case is fully assembled and the case screws are fully tightened.

5. Addressing

The SDM-AO4 is a synchronously addressed datalogger peripheral. Control Ports 1, 2, and 3, are used to address an SDM-AO4 and send out the digital millivolt readings for subsequent analog output. Addressing allows multiple SDM peripherals to be connected to one datalogger.

The SDM-AO4 has sixteen possible addresses, as shown in Table 2. The address for an SDM-AO4 is hardware selectable using jumpers at locations J12 and J8, as shown in Figure 2. The jumper at location J12 represents the least significant digit (LSD), and the jumper at location J8 is the most significant digit (MSD). The digit zero (0) is nearest the edge of the board, and the digit three (3) is the innermost jumper on the board. All SDM-AO4s are shipped with the address set at zero (00).

Table 2. SDM-AO4 Addressing			
Base 10 [CRBasic Loggers]	Base 4 [CR10(X), 21X, CR23X]	MSD J8	LSD J12
0	0	0	0
1	1	0	1
2	2	0	2
3	3	0	3
4	10	1	0
5	11	1	1
6	12	1	2
7	13	1	3
8	20	2	0
9	21	2	1
10	22	2	2
11	23	2	3
12	30	3	0
13	31	3	1
14	32	3	2
15	33	3	3
MSD = most significant digit LSD = least significant digit			
Multiple SDM-AO4s connected to one datalogger must have separate and sequentially increasing addresses.			

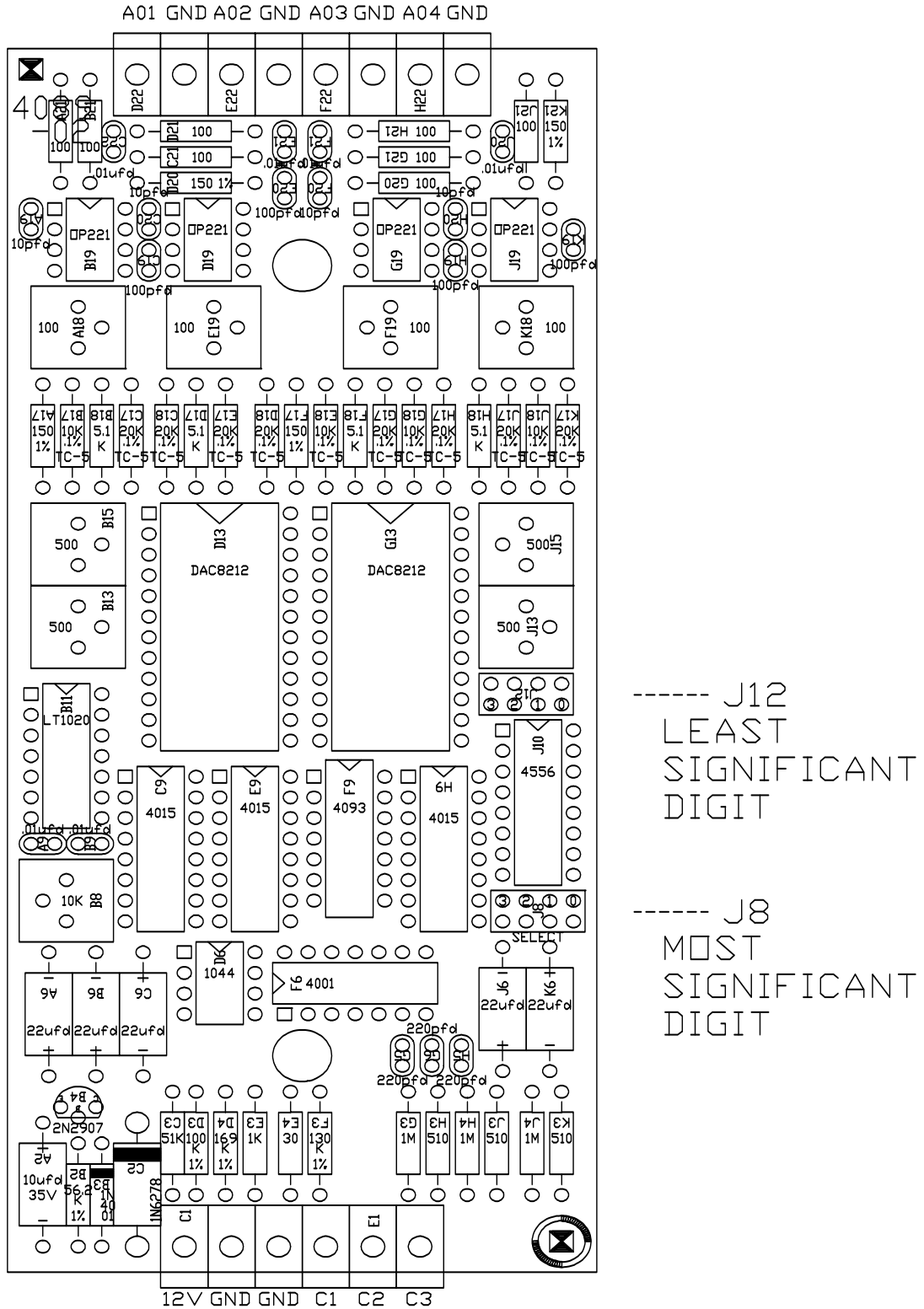


FIGURE 2. Locational Diagram for the Address Jumpers.

6. Programming

NOTE This section is for users who write their own datalogger programs. A datalogger program can be generated using Campbell Scientific's SCWIN Short Cut Program Generator. You do not need to read this section to use Short Cut.

The datalogger is programmed using either CRBasic or Edlog. Dataloggers that use CRBasic include our CR800, CR850, CR1000, CR3000, and CR5000. Dataloggers that use Edlog include our CR7, CR10X, CR10, CR23X, and 21X. Both CRBasic and Edlog are included in PC400 and LoggerNet datalogger support software.

In both CRBasic and Edlog, the datalogger programming instruction allows the user to set four separate voltage levels in one SDM-AO4, or move voltage levels with multiple SDM-AO4s. Voltage levels are reset each time the instruction is executed. The voltage range is ± 5 Volts; voltage levels sent to the SDM-AO4 which are out of the range limits will appear as either + 5 Volts or - 5 Volts depending on whether it is overranged or underranged.

6.1 CRBasic

6.1.1 SDMAO4 Instruction

The SDMAO4 instruction is used to set the voltage to an SDM-AO4 four channel analog output device.

NOTE The SDMAO4 instruction was at one time named the AO4 instruction. Please change your program accordingly.

The SDMAO4 instruction has the following syntax:

SDMAO4([Source](#), [Reps](#), [SDMAddress](#))

Description of the parameters follows:

Source: The Source parameter is the variable or variable array that holds the voltage(s), in millivolts, that will be sent to the SDM-AO4(s). If multiple SDM-AO4s are to be triggered with one instruction, this parameter must be dimensioned to the total number of channels for all the devices being set (e.g., if all four channels are being set on two SDM-AO4 devices, Source must be dimensioned to eight).

Reps: The Reps parameter determines the number of SDM-AO4 output channels that will be set. If this parameter is greater than four (i.e., voltage is being set for more than one SDM-AO4 device), voltage is set on the next consecutively addressed SDM-AO4 device. In this case, the SDM-AO4s must have sequential SDM addresses.

SDMAddress: The SDMAddress parameter defines the address of the SDM-AO4 to which a voltage should be applied. Valid SDM addresses are 0 through 14. Address 15 is reserved for the SDMTrigger instruction. CRBasic dataloggers use base 10 when addressing SDM devices (see Table 2).

6.1.2 SDMSpeed Instruction

The SDMSpeed instruction is used to change the bit period that the datalogger uses to clock the SDM data. Slowing down the clock rate may be necessary when long cable lengths are used to connect the datalogger and SDM devices.

The syntax of this instruction is as follows:

SDMSpeed ([BitPeriod](#))

The BitPeriod argument can be an integer or a variable. If the SDMSpeed instruction is not in the program, a default bit period is used. If 0 is used for the argument, the minimum allowable bit period is used. Table 3 shows the default, minimum allowable, and maximum bit period for each of our CRBasic dataloggers.

Datalogger	Default Bit Period	Minimum Allowable Bit Period	Maximum Bit Period
CR800, CR850	26.04 μ sec	8.68 μ sec	2.2 msec
CR1000	26.04 μ sec	8.68 μ sec	2.2 msec
CR3000	26.04 μ sec	8.68 μ sec	2.2 msec
CR5000	30 μ sec	8 μ sec	3 msec

The equation used to calculate the bit rate depends on the datalogger used. The datalogger will round down to the next faster bit rate.

Equation for CR800, CR850, and CR1000:

$$\text{bit_rate} = \text{INT}((k * 72) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=8.68 microseconds

Equation for CR3000:

$$\text{bit_rate} = \text{INT}((k * 144) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution= 4.34 μ sec.

Equation for CR5000:

$$\text{bit_rate} = \text{INT}(k * 20) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=50 nsec.

6.2 Edlog

The Edlog dataloggers are programmed with the SDM-AO4 Instruction 103 (See Table 4):

SDM-AO4 (P103)

1: 1 Reps
2: 00 SDM Address
3: 0000 Loc [_____]

The number of repetitions, Parameter 01, specifies the total number of SDM-AO4 output channels to be set. The address of the first SDM-AO4 is specified with Parameter 02, multiple SDM-AO4s must have consecutive addresses. Parameter 3 is the starting Input Location containing the first millivolt level to be output on the first channel of the first SDM-AO4. Subsequent millivolt levels must be contained in consecutive Input Locations immediately after the first Input Location specified in Parameter 3.

For example, two SDM-AO4s can be used to output eight voltage levels which are contained in Input Locations 15 through 22. There are eight repetitions, so eight (8) will be entered for Parameter 1. The SDM-AO4s must have consecutive addresses (e.g., 31 and 32), and Parameter 2 would contain 31 in this case. Fifteen (15) will be entered for Parameter 3.

TABLE 4. Description of Instruction 103

Par. No.	Data Type	Description
01:	2	Reps - Number of analog outputs.
02:	2	Address of SDM-AO4 in base 4 (00 to 33)
03:	4	Input Location containing millivolt output level
Execution Time: 1.0 ms + (0.8 ms) * R (R=Repetitions)		

6.3 Programming Examples

The following program examples are given to help the user understand the general principles involved in the use of the SDM-AO4 with CSI dataloggers.

Both of the example programs are for weather stations with a datalogger measuring wind speed, wind direction, temperature, and relative humidity. Each parameter is then scaled to 0 to 1000 mVDC, and output to a strip chart recorder through the SDM-AO4.

6.3.1 CR5000 Program Example

Although this program is for a CR5000 datalogger, programming for other CRBasic dataloggers is similar.

```
'CR5000 SDM-AO4 Program Example

Public WS_ms
Public WD_0_360
Public Temp_C
Public RH
Public WD_0_540
Public Flag
Public AO4Output(4)

Alias AO4Output(1) = WSOut
Alias AO4Output(2) = WDOut
Alias AO4Output(3) = TempOut
Alias AO4Output(4) = RHOut

'Code for DataTable OneMin
DataTable(OneMin,1,-1)
  DataInterval(0,1,Min,0)
  WindVector (1, WS_ms,WD_0_360, IEEE4, 0, 0, 0, 0)
  Average(1,Temp_C,IEEE4,0)
  Sample(1,RH, IEEE4)
EndTable

BeginProg
  Scan(1,Sec,1,0)
  '   Code for 03001 wind measurements, WS_ms & WD_0_360:
  PulseCount(WS_ms, 1, 1, 1, 1, 0.75, 0.2)
  BrHalf(WD_0_360, 1, mV1000, 1, 1, 1, 1000, True, 1000, 250, 355, 0)
  '   Code for CS500 measurement, AirTC and RH:
  VoltSE(Temp_C,1,mV5000,3,0, 0, _60Hz,0.1,-40.0)
  VoltSE(RH,1,mV5000,2,0, 0, _60Hz,0.1, 0)
  '   Call Data Table
  CallTable(OneMin)

  '   Convert 0-360 WD to 0-540:
  If WD_0_540 >= 270 and WD_0_360 <180 Then
    WD_0_540 = WD_0_360 + 360
  Else
    WD_0_540 = WD_0_360
  EndIf

  '   Scale the measurements for the SDM-AO4 to output 0-1000 mV
  WSOut = WS_ms*20      'WS: 0-50 m/s = 0-1000 mV
  WDOut = WD_0_540 *1.859 'WD: 0-540 deg = 0-1000mV
  TempOut= 10*(Temp_C+40) 'Temp: -40-60 deg C = 0-1000 mV
  RHOut = RH *10      'RH: 0-100 % RH = 0-1000 mV
  '   Send mV outputs to SDM-SIO4
  SDMAO4 (AO4Output(),4,12)
  NextScan
EndProg
```

6.3.2 CR10X Program Example

Although this program is for a CR10X, programming for other Edlog dataloggers is similar.

```

;{CR10X}
*Table 1 Program
 01: 1.0000      Execution Interval (seconds)

; Code for 03001 wind measurements, WS_ms & WindDir:

1: Pulse (P3)
 1: 1           Reps
 2: 1           Pulse Channel 1
 3: 21          Low Level AC, Output Hz
 4: 1           Loc [ WS_ms   ]
 5: 0.75        Mult
 6: 0.2         Offset

2: Excite-Delay (SE) (P4)
 1: 1           Reps
 2: 5           2500 mV Slow Range
 3: 1           SE Channel
 4: 1           Excite all reps w/Exchan 1
 5: 2           Delay (0.01 sec units)
 6: 2500        mV Excitation
 7: 2           Loc [ WD_0_360 ]
 8: 0.142       Mult
 9: 0           Offset

; Code for CS500 measurement, AirTC and RH:

3: Volt (SE) (P1)
 1: 1           Reps
 2: 25          2500 mV 60 Hz Rejection Range
 3: 3           SE Channel
 4: 3           Loc [ Temp_C   ]
 5: 0.1         Mult
 6: -40.0       Offset

4: Volt (SE) (P1)
 1: 1           Reps
 2: 25          2500 mV 60 Hz Rejection Range
 3: 2           SE Channel
 4: 4           Loc [ RH      ]
 5: 0.1         Mult
 6: 0           Offset

; Output Data Every Minute

```

```

5: If time is (P92)
  1: 0      Minutes (Seconds --) into a
  2: 1      Interval (same units as above)
  3: 10     Set Output Flag High (Flag 0)

6: Set Active Storage Area (P80)                ;Set array ID to 101
  1: 1      Final Storage Area 1
  2: 101    Array ID

7: Real Time (P77)                             ; Output Year, Day, Hour/Minute
  1: 1110   Year,Day,Hour/Minute (midnight = 0000)

8: Wind Vector (P69)                           ; Output Average WS, WD, StdDev WD
  1: 1      Reps
  2: 0      Samples per Sub-Interval
  3: 0      S, theta(1), sigma(theta(1)) with polar sensor
  4: 1      Wind Speed/East Loc [ WS_ms   ]
  5: 2      Wind Direction/North Loc [ WD_0_360 ]

9: Average (P71)                               ; Output Average Temperature
  1: 1      Reps
  2: 3      Loc [ Temp_C   ]

10: Sample (P70)                              ; Sample RH
  1: 1      Reps
  2: 4      Loc [ RH      ]

; Routine to convert 0-360 deg. Direction to 0-540 deg.

11: Do (P86)
  1: 21     Set Flag 1 Low

12: If (X<=>F) (P89)                          ; Set Flag 1 if previous
  1: 9      X Loc [ WD_0_540 ]                ; reading was > 270
  2: 3      >=
  3: 270    F
  4: 11     Set Flag 1 High

13: Z=X (P31)                                 ; Set 0-540 value to current 0-360 reading
  1: 2      X Loc [ WD_0_360 ]
  2: 9      Z Loc [ WD_0_540 ]

14: If (X<=>F) (P89)                          ; If current reading is <180
  1: 9      X Loc [ WD_0_540 ]
  2: 4      <
  3: 180    F
  4: 30     Then Do

15: If Flag/Port (P91)                       ; And if previous reading
  1: 11     Do if Flag 1 is High              ; was > 270
  2: 30     Then Do

```

```

16: Z=X+F (P34) ; Add 360 to the current reading
   1: 9          X Loc [ WD_0_540 ] ; otherwise, the current reading
   2: 360        F ; is left alone
   3: 9          Z Loc [ WD_0_540 ]

17: End (P95)

18: End (P95)

; Scale the measurements for the SDM-AO4 to output 0 to 1000 mV

19: Z=X*F (P37) ; Scale WS: 0-50 mps = 0-1000 mV
   1: 1          X Loc [ WS_ms ]
   2: 20         F
   3: 5          Z Loc [ WSoutput ]

20: Z=X*F (P37) ; Scale WD: 0-540 deg = 0-1000 mV
   1: 9          X Loc [ WD_0_540 ]
   2: 1.859      F
   3: 6          Z Loc [ WDoutput ]

21: Z=X+F (P34) ; Scale Temperature: -40-60 deg C = 0-1000 mV
   1: 3          X Loc [ Temp_C ]
   2: 40         F
   3: 7          Z Loc [ TempOut ]

22: Z=X*F (P37)
   1: 7          X Loc [ TempOut ]
   2: 10         F
   3: 7          Z Loc [ TempOut ]

23: Z=X*F (P37) ; Scale RH: 0-100 % RH = 0-1000 mV
   1: 4          X Loc [ RH ]
   2: 10         F
   3: 8          Z Loc [ RHout ]

; Send mV outputs to SDM-AO4

24: SDM-AO4 (P103)
   1: 4          Repts
   2: 30         SDM Address
   3: 5          Loc [ WSoutput ]

End Program

```


Campbell Scientific Companies

Campbell Scientific, Inc. (CSI)

815 West 1800 North
Logan, Utah 84321
UNITED STATES

www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)

PO Box 2450
Somerset West 7129
SOUTH AFRICA

www.csafrica.co.za • cleroux@csafrica.co.za

Campbell Scientific Australia Pty. Ltd. (CSA)

PO Box 444
Thuringowa Central
QLD 4812 AUSTRALIA

www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)

Rua Luisa Crapsi Orsi, 15 Butantã
CEP: 005543-000 São Paulo SP BRAZIL

www.campbellsci.com.br • suporte@campbellsci.com.br

Campbell Scientific Canada Corp. (CSC)

11564 - 149th Street NW
Edmonton, Alberta T5M 1W7
CANADA

www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)

300 N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA

www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)

Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM

www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Ltd. (France)

Miniparc du Verger - Bat. H
1, rue de Terre Neuve - Les Ulis
91967 COURTABOEUF CEDEX
FRANCE

www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific Spain, S. L.

Psg. Font 14, local 8
08013 Barcelona
SPAIN

www.campbellsci.es • info@campbellsci.es

Please visit www.campbellsci.com to obtain contact information for your local US or International representative.